New analyses on the development of early rice cultivation systems in India

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Introduction

There is a small, but growing, dataset of weed seeds and phytolith assemblages to complement the record of Neolithic, Chalcolithic and Iron Age rice in India. Here we compile evidence for morphological diversity in rice phytoliths and increases in rice grain size that starts after the Neolithic, suggesting cultivation. Weed assemblage data suggests that the earliest cultivation was based on natural flood or rainfall regimes, with increasing evidence for irrigated rice fields by the Iron Age (from c.1000 BC), after which wetfield rice cultivation spread more widely in South Asia.

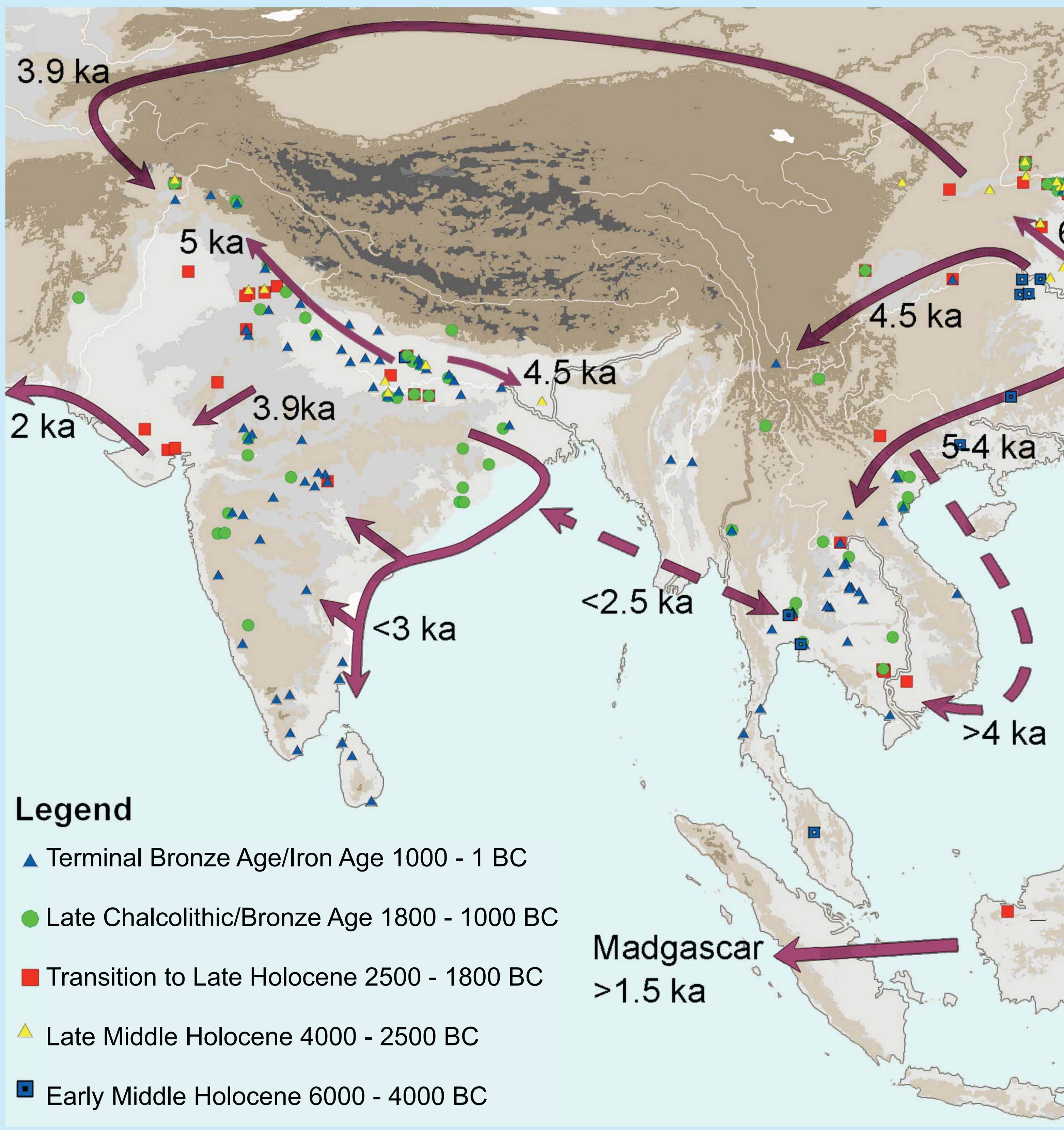
Research Aims and Questions

Current work aims to determine an identification criteria for different rice cultivation systems based on associated weed assemblages, and to track the past distribution of these systems within South Asia.

- Which rice cultivation systems were in use, and where, in Prehistoric/ Early Historic India?
- Which other crops were being grown within these systems?
- Can we distinguish between early wild rice and early domestic rice cultivation?
- Can we distinguish between *Oryza sativa indica* and *O. s. japonica*?

The Spread of Rice in India

Two possible areas of domestication are hypothesized, based on wild rice's native range: the Gangetic Plains and Orissa. Early, probably wild, rice use dates to c.8000-6000 BC in the Ganges. Orissa is poorly studied, however, suggestive evidence for other domesticates, e.g. pigeonpea, has been recovered by 1400 BC (Harvey *et al* 2006). By c.2000-1700 BC domestic rice cultivation occurs across Northern India in association with sedentary settlement, domestic livestock and winter crops (e.g. West Asian cereals, pulses and millets). Genetic and archaeobotanical evidence suggests *O. s. japonica* entered NW India c.1900-1400 BC, eventually resulting in *O. s. indica*. Further spread, to the rest of the continent, came c.500 BC, after the development of irrigation systems (Fuller and Qin 2009, Fuller *et al* 2010).



Early Rice Cultivation Systems

Three main cultivation systems existed in Prehistoric-Early Historic South Asia, and these systems continue to be practiced today providing useful ethnoarchaeological analogs.

Rainfed cultivation
Early rice cultivation in Northern India. Occurring in lowlands or uplands.

Irrigated cultivation
Developed c.1000 BC. Spread with urbanism and buddhism.

Shifting cultivation
Began ?? Developed from rainfed cultivation. Often occurs in uplands.

Koldihwa, Uttar Pradesh: 2000-1000 cal. BC

Macrobotanic and phytolith evidence from this site suggests the development of year round occupation and changes in crop processing strategies (from individual to communal processing) in the Chalcolithic. Agriculture focused on rice, wheat, barley and millet cultivation throughout the sequence; a combination of summer and winter crops. The weed assemblage does not contain water loving species, e.g. *Commelina benghalensis* or *Fimbristylis* sp., suggesting either dryland rice cultivation or wild rice gathering, and that irrigation was a later development in North India.

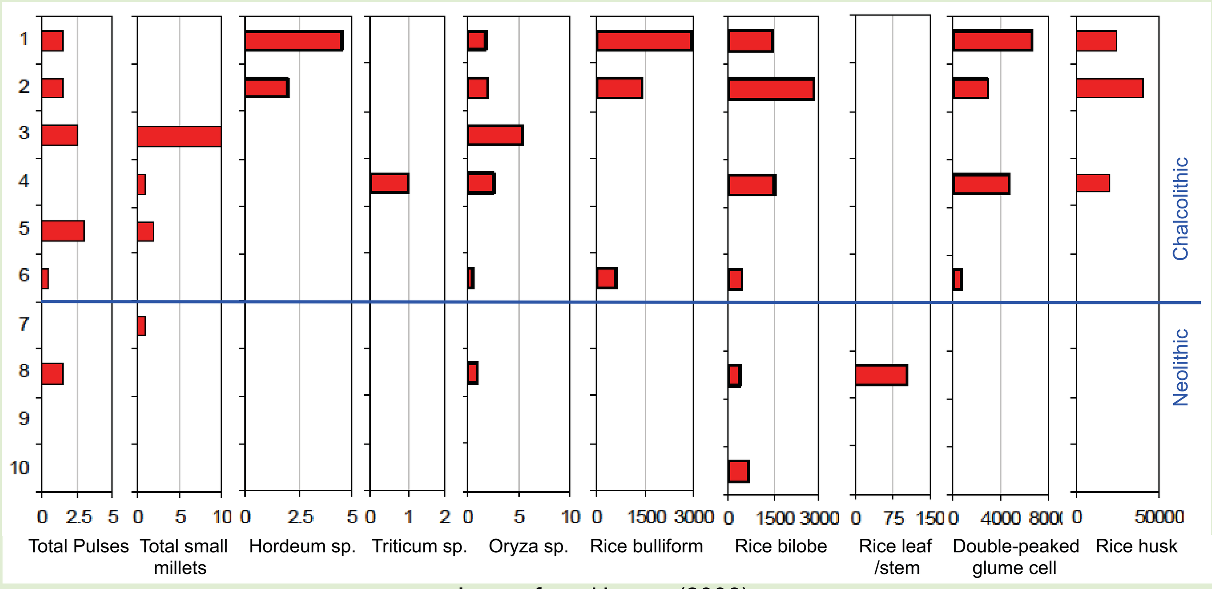
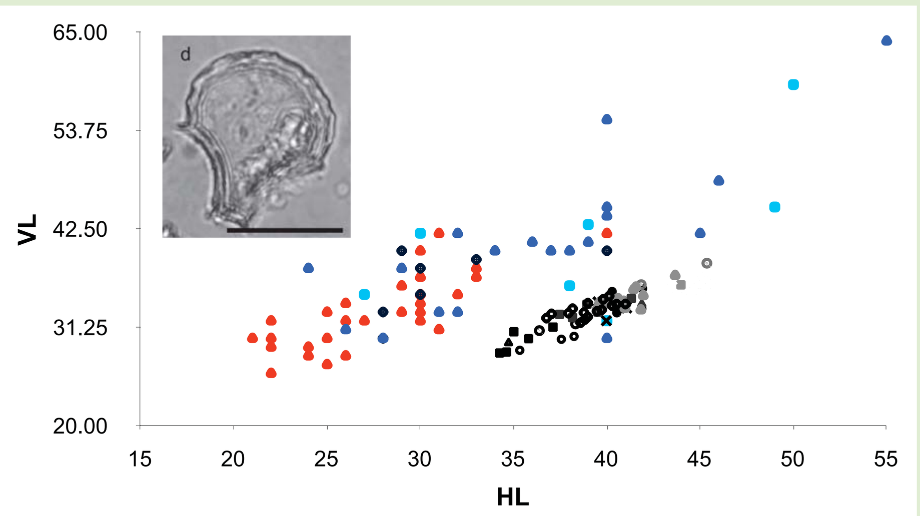


Image from Harvey (2006)

Phytolith Morphometrics

A proposed method of distinguishing between *O. s. indica* and *O. s. japonica* involves morphometric analysis of rice fan-shaped bulliforms (cuneiform bulliforms) (Zheng *et al* 2003). Whilst this method may work on modern rice samples, archaeological bulliforms do not show such clear differentiation. We suggest that environmental factors affect bulliform morphology to a greater extent than genetics. The difference in UCL and Japanese data (right) may be explained by differing sample processing methods.



Grey scale = *O. s. japonica* from Zheng *et al* (2003). Blue = archaeological Indian (probably *O. s. indica*) processed at UCL. Red = archaeological Chinese (probably *O. s. japonica*) processed at UCL.

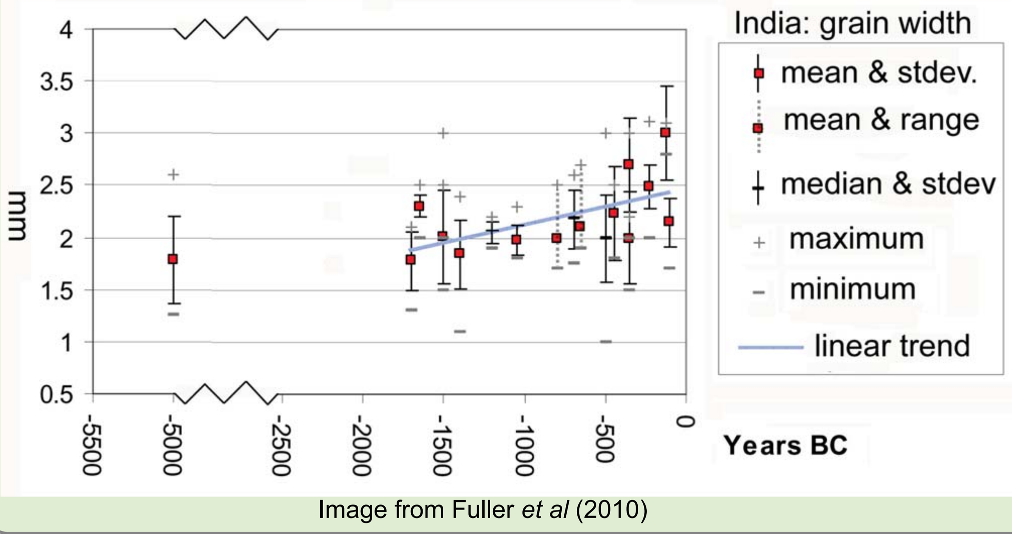


Image from Fuller *et al* (2010)

Grain Size

Cereal domestication often leads to increased grain size, a pattern that can be seen in Indian rice. This trait develops over an extended period of time, starting c.2000 BC. In areas with wild stand of rice, e.g. the Gangetic Basin, it takes longer for grains to become bigger, suggesting recurrent gene flow from wild populations of rice.

Weeds of Cultivation

Many of the arable weeds present in the archaeological record may be collected as food plants. In particular, some millets (e.g. *Echinochola* spp. or *Paspalum scrobiculatum*) can be seen as important crops in some situations, or weeds of rice in others. Although weed data is rare in Indian archaeobotany reports, we have a data set that includes many key species for identifying rice cultivation systems, particularly irrigated systems. For example:

Ischaemum rugosum (Saromacca grass)

Common weed of irrigated rice across Asia, subaquatic. Found with rice at Neolithic sites situated in riverine environments in North and East India.

Image ©IRRI

Image from WikiCommons

Commelina benghalensis (Benghal dayflower)

Common in moist soils across Asia. Subaquatic in rice paddy. Increased occurrence in the Early Historic period in North India.

Early Rice Project UCL

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Zheng et al. (2004) Phytoliths of rice detected in the Neolithic sites in the valley of the Taihu Lake in China. *Environmental Archaeology*. **8**:177-184.